LBNL-182539

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Lights, Cameras, Action… and Cooling – The case for centralized low carbon energy at Fox Studios

Alastair Robinson, Cynthia Regnier
Building Technologies and Urban Systems Division, Energy Technologies Area

May, 2015

DISCLAIMER

Lights, Cameras, Action... and Cooling – The case for centralized low carbon energy at Fox Studios

Overhead view of Fox Studios site.

Source: Fox Studios

Project Type	Film Studios Production Stages and Central Plant, Retrofit
Climate Zone	ASHRAE Climate Zone 3B, Warm and Dry
Ownership	Private
Barriers Addressed	Existing energy management practices, lack of measured energy data, visual and functional performance needs in a constrained environment
Square Footage of Project	~175,000 (Large Stages and other central cooling—connected buildings)
Expected Energy Savings (vs. existing energy use)	~34% (Large Stage) ~55% (Central cooling plant)
Actual Energy Savings (to be verified)	~2,800,000 kWh / yr electricity
Expected Cost Savings	~$18,000 (Large Stage) ~$330,000 (Central cooling plant)
Project Simple Payback	>20 years (Large Stage) ~6 years (Central cooling plant)
Actual Cost Reductions	~$23,000 (Large Stage) ~$370,000 (Central cooling plant)
Expected Carbon Dioxide Emissions Avoided	~1,900 metric tons per year
Construction Completion Date	January 2014

NOTES:

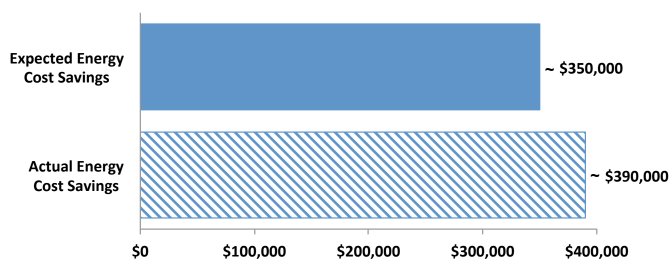
1. Project scope was significantly modified after the design stage to interconnect CP1 and CP2 and removing the medium production stage retrofit. These modifications account for changes to floor area, energy and energy cost savings and carbon emissions reductions.
2. Cost reductions based on a utility rate of $0.14/kWh.
3. Emissions calculated using the Greenhouse Gas Equivalencies Calculator.

Overview

Fox Studios partnered with the U.S. Department of Energy (DOE) to develop and implement solutions to retrofit a production stage and the central cooling plant on its film production studio campus, to reduce energy consumption by at least 30% as part of DOE's Commercial Building Partnerships (CBP) Program. Although this case study reports measured energy savings arising from retrofits to a unique building type with unusual load characteristics, the EEMs implemented for the central plant are applicable to any large campus, office and higher education facility. The intent is that by making the energy-efficiency measures (EEMs) set that were implemented as part of this project applicable to a larger number of buildings on the campus, Fox Studios will be able to implement an integrated campus-wide energy strategy for the long term.

There were significant challenges for this project in the design phase, which included identifying how to assess and analyze multiple cooling system types and develop a coherent strategy for assessment and analysis. Within these broad areas, the focus was on how to implement the measurement and verification activities to collect the appropriate data (in terms of capturing 'normal' operating characteristics and granularity) and determine the best approach to providing cooling to the production stages based on the nature of existing systems and the expected improvement in energy performance of the central cooling plant. The method adopted for analysis of energy savings from the measured data after the EEM set was implemented required a high degree of creativity and ingenuity given the complexities of system interactions at the central plant and the limited data collected at the production stage.

Whole-Campus Annual Energy Cost Reductions



1. The Commercial Building Partnerships (CBP) program is a public/private, cost-shared initiative that demonstrates cost-effective, replicable ways to achieve dramatic energy savings in commercial buildings. Through the program, companies and organizations, selected through a competitive process, team with U.S. Department of Energy (DOE) and national laboratory staff who provide technical expertise to explore energy-saving ideas and strategies that are applied to specific building project(s) and that can be replicated across the market.

Also, as the project evolved the objective changed, along with the solutions. As such, both expected and actual energy savings vary significantly from what was projected during early design. The analytical framework utilized provides a blueprint for similar projects at other large commercial building campuses.

Fox Studios worked with Lawrence Berkeley National Laboratory (LBNL) and its consultants that were part of the CBP program, to determine appropriate energy-efficient designs, operations and an appropriate set of EEMs. The majority of energy reductions came from a reduction in cooling energy, with measured energy reductions assessed at approximately 34% annually at the large production stage, and approximately 55% for the central cooling systems. The CBP technical team suggested additional efficiency measures to further reduce energy use at the central plant, which Fox Studios will assess and implement on a case by case basis according to the degree to which they complement Fox's overall site energy strategy and commercial requirements.

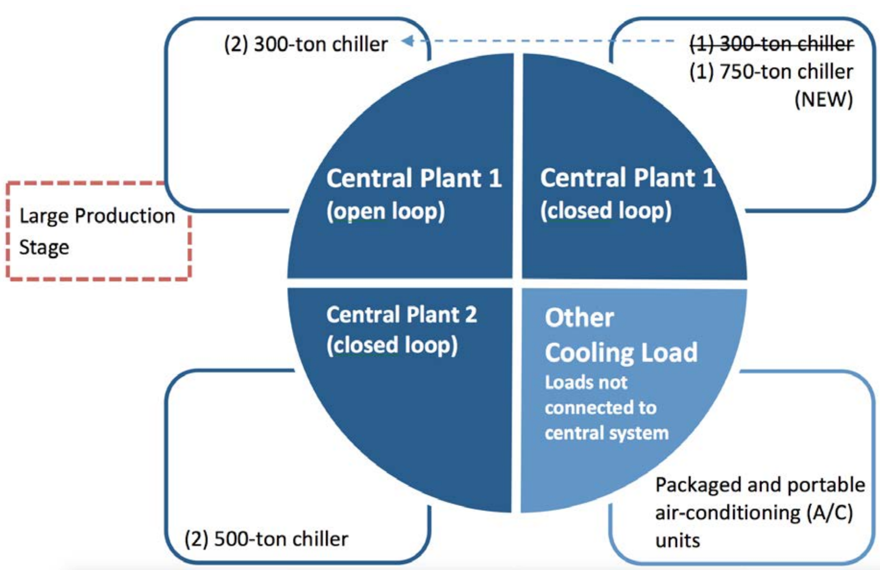
Fox Studios is the television and feature film production arm of 21st Century Fox, and is located in west Los Angeles, California. The Fox Studios campus consists of a large complex of 15 production stages and several other buildings that range in age (dating back to the 1920s). The studio buildings are large single-zone spaces that typically do not have windows, and have an interior height of 40–50 feet. The need for powerful, high-quality production lighting drives the studio's overall energy demands, particularly for cooling to offset the heat produced by that lighting. These physical characteristics and the unpredictable patterns of use associated with production facilities present a challenge in meeting energy needs. Similar challenges may arise at other large multi-building campuses, such as conference centers, entertainment venues, and large health-sector facilities.

Historic Systems and Performance Needs Create Challenges

During the design phase representative production stage building types were identified, which shared common characteristics in terms of geometry, construction, internal loads, and HVAC system type. The production stage types were used to inform decision making related to the analysis and implementation of energy-efficiency measures across the campus. The assessment of the production stages focused on two types: a large production stage and a medium production stage. One representative production stage for each type was selected based on the ability for their production schedules to accommodate the installation of monitoring equipment and evaluation of EEMs while still allowing filming activities during the baseline energy measurement period. The performance data gathered during this period was essential to not only understanding the energy consumption of the production stages, but also how the production stages influenced the central plant.

Production stage energy loads are typically dominated by production lighting, both in terms of their contribution to the overall lighting energy load and their impact on the cooling load. Despite this seemingly obvious opportunity for energy saving, requirements placed on the output characteristics of production lighting are such that to date no acceptable energy-efficient alternative has been identified, and replacement was not an option for the project. However, house lighting, which is used when staging activities between filming, does not have these requirements — the updating of lamps to LEDs resulted in energy-saving.

Cooling systems offered the greatest potential for energy savings. In this case they were the most difficult to analyze and evaluate due to the multiple central plants and subsequent multiple separate chilled water loops currently servicing different production stages and buildings on the campus. To manage this level of complexity an analysis approach was developed that started with the two types of production stages. For each of the types of production stages the first step was to determine the heat gain that arises from both production and house lighting. Even among the different stage types there is significant variance according to size, the lighting requirements specified by the studio user and the studio's operating schedules, which are influenced by the type of production being filmed. The operating schedule was one of the key criteria for selection of each production stage as continued use over the course of the monitoring period was essential in providing insight into energy



use of each stage type. By selecting a representative production stage for each type, launching monitoring equipment, and gathering actual measured data for a period of time (in this case two months), the larger set of production stages were characterized and more educated input values developed for the energy model and other analysis models. By using results of the energy and heat gain analysis in energy modeling, plus additional measurement and verification efforts, the project team was able to prioritize methods for improving efficiencies of water-side and air-side cooling systems in the production stages. In addition they were able to analyze the impact of different efficiency measures related to cooling at the production stage type level and to analyze the impacts at the chilled water loop level relating to the central plant.

The retrofits for the production stages were a key part of the puzzle to develop a high-efficiency central cooling system for the whole site, which provides the greatest potential for leveraging the inherent scale economies, and achieving greater energy savings. The EEMs implemented needed to be flexible to effectively meet the requirements of a space that is frequently reconfigured, support air stratification in the stage area to keep generated heat out of the occupied zone, and keep people cool in specific locations, especially at floor level. So, in addition to the house lighting efficiencies, the production stage EEMs implemented included an air handler upgrade, including automatic airside economizers, and redesigned air distribution ductwork with motorized dampers and controls. The improvement to air distribution includes a new relief air system. Taking return air from medium level (and therefore lower temperature return air than that currently taken at high level due to stratification) reduces the load on the air handler. The relief air system, which used to rely on natural stratification to push warm air out, utilizes fans to more effectively remove warm air by mechanical means.

In a similar fashion as the approach taken with the production stages, the central plants were assessed to identify the best opportunity to establish a series of models that could effectively capture the dynamics of the central plant, and analyze what efficiency measures provided the greatest potential for energy savings. However, as with the production stages, the closer the team looked, the greater the degree of complexity discovered. In addition to the multiple central plants, multiple chilled water loop types (open and closed), and the various types of equipment, the age of the equipment was a factor as well, since it was discovered some of the air handling units date back to the 1930s. The original and existing heating, ventilating and air conditioning (HVAC) systems deployed across the campus was grouped into four categories:

- Central Plant 1 (CP1): 1 open loop
- Central Plant 1 (CP1): 1 closed loop
- Central Plant 2 (CP2): 1 closed loop
- Other Cooling Plant (decentralized technologies, such as portable chillers)

To manage the complexity the team initially focused on CP1 for the two chilled water loops, one which was open and the other closed. To develop useful models to effectively represent this complexity the team again used a combination of M&V and different

Central plant chilled water pumps and pipes prior to insulation.
Source: Fox Studios

types of models to refine, evaluate and calibrate the models. Numerous discoveries were made along the way, which led to approaches like comparing kW/ton across the load range to assess if it was beneficial to connect air cooled and/or portable systems to the central plant. Following some redesign, the scope of the project was modified to include interconnection of CP1 and CP2, in order to maximize the potential for energy savings.

Decision Criteria

The EEMs selected for Fox Studios, including the central cooling plants and the large production stage, went through several analysis cycles before a preferred set was identified. The CBP technical team recommended EEMs based on the results of energy modeling and parametric analysis, utilizing the measured performance data of pre-retrofit conditions in the analysis. The EEMs selected had to be cost-effective and consistent with the project objectives.

Maintenance and Operations

Many of the cooling systems and the buildings in which they were utilized were not centrally monitored or controlled — in these cases, cooling supply and central plant chiller operation were not efficiently matched with demand. This situation resulted in sub-optimal cooling distribution, and led to challenges with providing cooling where required. There was also a significant labor burden associated with the existing approach to controls and maintenance of adequate system capacity. To increase cooling supply to a stage maintenance staff had to walk to the mechanical room of each stage to open the chilled water supply valves. When it appeared that distributed cooling capacity from the plant was maximized and additional cooling was needed, portable equipment, consisting of portable packaged air-conditioning units and portable cooling towers with connected fan coil units, were deployed to the required site. Implementation of centralized control, connection of an additional chiller and interconnection of the existing cooling pipe loops removes both of these issues.

Economic

Fox Studios' payback criteria of net-positive present values less than 10 years using a discount rate of 8 percent (plus 10% electricity rate escalation) are similar to other private-sector institutions. However, since some of its current building energy systems had reached the end of its useful life, without these improvements, future labor and operating costs, such as those from procuring and operating more portable, inefficient a/c units threaten to become prohibitive. The target discounted payback for efficiency measures was therefore less stringent than it might otherwise have been, due to the cost associated with continuing to operate the current systems, and given forecast growth in the studio's requirement for cooling capacity.

The following economic conclusions were drawn:

- Measures that did not require purchasing new equipment, such as re-commissioning or implementing new control strategies and optimizing existing sub-systems, were preferred.
- EEMs targeting the central plant were prioritized over those targeting the production stage because they would produce savings across the current plant as well as for buildings or production stages added to the system in the future.

Design

The main objective is transition of the current cooling system: a mixture of types and eras spread across four production stages and eight other buildings, to a centrally controlled, efficiently operated plant. The evaluation of scenarios that connect more buildings to this system was a primary factor in the development of a new campus energy strategy. The first stage in developing this strategy was to 1) reduce cooling load at stages (and subsequently load on the central plant), 2) examine the options for improving cooling plant efficiency and reducing the use of open loop systems by transitioning to closed coil strategies, and 3) evaluate HVAC system designs at the stage level against the efficiency of the improved central plant design to come up with a cost-benefit analysis of connecting stages to the central plant and reducing reliance on portable, inefficient equipment. Identifying complementary approaches at the central plant and the production stages is crucial to overall energy performance and realizing the potential cost savings.

The final design also needed to be sufficiently flexible to meet different filming arrangements, while also operating very quietly and with very little vibration.

Policy

Fox Studios' parent company, 21st Century Fox, is committed to reducing its climate impact through reduction in energy use, carbon emissions, and use of renewable energy where economically feasible.

For carbon emissions, the goal is to reduce emissions by 15% per shoot-day for feature films and 10% per episode for television productions with an overall goal of reducing emissions intensity per unit revenue by 25% by the year 2020. Establishing a transparent methodology and tools to calculate reductions is part of this goal. Reducing energy use is a key element for delivering on the carbon reduction goals.

Renewable energy projects are judged on a case-by-case basis according to the characteristics of the site and the key economic criteria, such as local utility rates and implementation costs.

Energy-Efficiency Measures Snapshot

The following table summarizes the EEMs considered for the large production stage and the central plant, along with their expected savings, costs, simple payback, and cost of conserved energy. This analysis used the following considerations and assumptions:

- Energy-savings estimates were based on 3 months of measured data. For the large production stage, measured data consisted largely of intermittent and low load operation collected for a relatively short period of time. As a result, energy savings estimates are based on the average measured peak load.
- Energy savings and the economic cases for the central plant and the large production stage are likely to improve over time. For the central plant this will arise as more load is added to the closed loop cooling system. For the large production stage, this will occur as a result of longer operating hours and for higher peak cooling load conditions.
- To calculate the cooling savings for the production stage EEMs, a central plant cooling efficiency of 0.662 kW/ton was utilized — this is equivalent to the proposed central plant efficiency and ensured that the retrofit energy reductions were appropriately allocated.
- The HVAC energy efficiency measures at the production stage were selected from a range of potential options, and the upgrade of CP1 was developed as an option during pre-design. The upgrade of CP2 and connecting the two central plants was developed later in the design stage and was implemented on the basis of results of analysis completed for the interconnection option compared with the proposed CP1-only retrofit.
- Payback periods for some EEMs proposed for the Large Production Stage were higher than the 10 year threshold — these were adopted as replacement was necessary due to equipment end-of-life.

Energy-Efficiency Measures for the Fox Studios Central Plant and Production Stages

	Implement at Fox	Consider for Future	Annual Savings (kWh/year)		Annual Savings ($/year)		Actual Improvement Cost	Simple Payback,	Cost of Conserved Energy (CCE),[3]
	Yes/No	Yes/No	Expected	Actual	Expected	Actual	$	Years	$
Central Plant (94% Central Cooling Energy Savings)[2]									
Install variable frequency drives and variable valve controls on chilled water pumps	Yes	Yes							
Implement staging controls for condenser water pumps	Yes	Yes	310,000	340,000	43,000	48,000			
Implement condenser water temperature reset control based on outside air temperature *	Yes	Yes					~2,100,000	5.6	0.07
Retrofit chillers with variable frequency drives	Yes	Yes	620,000	690,000	86,000	96,000			
Convert chilled water system from open-loop to closed-loop	Partial	Yes	1,400,000	1,600,000	200,000	220,00			
Large Production Stage (6% Energy Savings)									
House Lighting (~1% of Energy Savings)									
Replace existing lighting with light-emitting diode (LED) fixtures	Yes	Yes	30,000	25,000	4,200	3,500	~31,000	8.7	0.10
HVAC (~5% of Energy Savings)									
Replace existing air-handling unit and include automatic air-side economizer	Yes	Yes							
Redesign air distribution system **	No	Yes	81,000	83,000	6,200	11,000			
Install rooftop exhaust with make-up air **	No	Yes					~700,000	36.7	0.48
Replace direct-evaporative cooling with closed circuit chilled water coil	Yes	Yes	100,000	54,000	7,800	8000			

* A climate-dependent EEM.

** Assumes incremental capital costs, as some plant capacity increase would be required.

Cost savings are based on an average blended utility rate of $0.14/kWh.

2. For the central plant EEMs, the actual design comprised interconnection of CP1 and CP2 — an option not considered in the early design phase. Expected and Actual energy and energy cost savings data reflects these project design modifications.

3. The CCE was evaluated with 8% discount rate for 25 years (Meier, 1984).

Note that in some cases, expected energy savings are shown for multiple HVAC technologies implemented together, as their operation is interdependent.

Energy Use Intensities by End Use

During the design phase, the technical expert team, led by Arup and CTG, studied central plant load operating characteristics, measured data, and historical production scheduling data to estimate peak and average daily cooling loads. The average cooling load data were then correlated to outdoor air temperature, and the correlation was applied to the local weather data to generate an hourly cooling load profile for use in the model simulations—not only for the central plant, but also for the production stages. The intent was to develop and implement a coherent campus-wide strategy to focus resources in terms of developing integrated technical solutions, and to standardize and streamline operations and maintenance practices. With regards to reducing overall cooling loads, the possible use of LEDs for production lighting was assessed, but it was clear that the technology does not yet produce light at the required color temperature or intensity for film production.

There were two goals to improving the central plant design — improve energy performance and increase capacity to enable redundancy. Overall, it was seen that with relatively simple energy efficiency upgrades to the central plant, it would be much preferred from an energy standpoint to make greater use of the chiller plant, and retire less efficient portable cooling plant. The retrofit implemented at the central plant provides greater site-wide energy security and enables chilled water to be dispatched with greater flexibility to the location of demand as required. The connection of CP1 and CP2 further supports this strategy, and central plant overall efficiency will continue to improve as further load is added.

Following the retrofit, energy performance was calculated based on detailed trend analysis and energy modeling. This was compared against energy performance of the pre-retrofit baseline to confirm energy and cost savings. For the central plant, the project team used a statistical energy model to determine operating characteristics of the central plant equipment. This approach utilizes measured trend data to develop relationships between energy efficiency and the various operating parameters of each piece of equipment in the system, to determine overall central plant energy performance.

The method was selected because it allows flexibility in terms of accommodating a custom combination of plant equipment types, the number of operating variables, and the custom operation and controls of the system — this was crucial due to the systems' inherent complexities. The data model, which is a collection of regression models connected through MATLAB Simulink, supports the description of performance for each individual equipment item under different operating conditions, and brings them together so the overall performance that reflects interaction of equipment and sub-systems may be simulated as a whole system. Calibrating the model to enable prediction of energy savings involves input of weather and cooling load data into the model to compare simulated versus measured performance. Once the error between the model and the measured data is within an acceptable tolerance — in this case, less than 5% — the model may be used to determine hourly and annual energy performance for both the pre and post-retrofit scenarios.

For the large production stage, modifications to the water-side systems comprised the replacement of the local open-loop direct evaporative cooling system with a closed chilled water coil, transferring this load from the open loop chilled water system to the closed loop chilled water system, thereby increasing load on the closed loop chiller and consequently increasing its operating efficiency. Improving chiller utilization in this way also enables improving staging strategies. Rather than always having two chillers operating at part load, the second chiller is only enabled once cooling requirements exceed the capacity of the primary chiller. Air-side modifications included replacement of the existing air handler with a new unit that incorporated a 100% outside air economizer. These measures reduce the reliance on energy inefficient portable cooling units.

Analyzing the operation of the production stage for the purpose of estimating annual energy savings was a challenge due to the limited post-retrofit trend data collected – the production stage was in intermittent operation for approximately nine percent of the post-retrofit data collection period, which translates into very low annual operating hours. As a result, the statistical correlations between equipment efficiency and operating conditions could not be fully developed. Peak load conditions were also significantly lower than experienced in the pre-retrofit case, and so the air handler was operating a part-load condition only, which meant that data representing the full operating range of the unit was not captured in the analysis. Instead, energy performance was measured based on the average peak cooling load during the data collection period, for which the equivalent part load plant efficiency was measured and extrapolated to represent one year of operation.

The lighting EEMs proposed at the design stage, and which focused on house lighting lamp replacement: installing compact fluorescent (CFL) and light-emitting diode (LED) fixtures for the medium and large production stages respectively, in place of incandescent bulbs, were implemented. The plan is to complete retrofit of LEDs to all stages by the end of 2016.

The central plant and production stage retrofits together contribute approximately 53% combined average energy savings for the cooling and lighting systems. The proposed designs target the most energy-intensive elements of the site, apart from production lighting, which is installed as needed by each film production crew, and therefore outside of the studio's scope.

Energy Model Results

Models 1 and 2, described below, show energy savings from the central cooling plant EEMs.

Model 1: Pre-retrofit Design, Central Plant

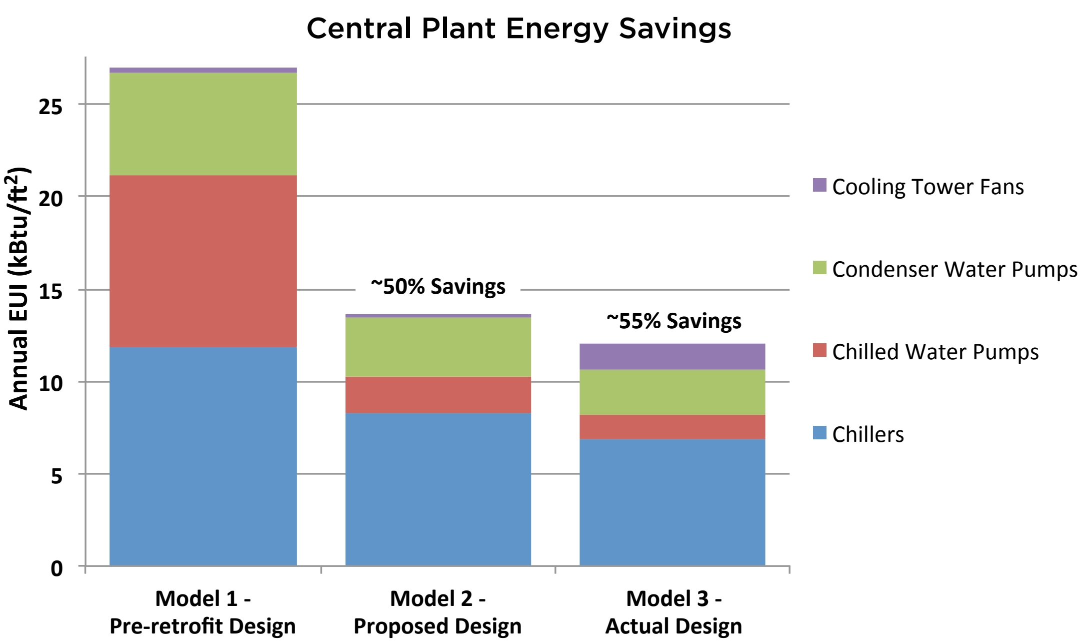
Model 1 represents the pre-retrofit operation of the central plant, which is assumed for connection to four of the large production stages, one scoring stage and 7 other production buildings (not assessed as building types for this project). This model has an annual energy use intensity (EUI) of about 27 thousand Btu per square foot (kBtu/ft^2).

Model 2: Proposed Design, Central Plant

Model 2 represents simulated performance of the proposed central plant design, which incorporates variable-speed control on the chilled water pumps, condenser water pumps, and chiller compressor. Also included are staging controls for the condenser water pumps, outside air temperature-based chilled water temperature reset, a conversion of a portion of the open-loop chilled water system to a closed-loop design, and interconnection of CP1 and CP2. Improvements in chiller staging will ensure that the multiple chillers of different capacities are appropriately prioritized to maximize part load efficiency. This model has an annual EUI of about 13.6 kBtu/ft^2.

Model 3: Actual Design, Central Plant

Model 3 represents the measured performance of the central plant design implemented, which incorporates all of the measures listed under Model 2. This model, for which data was collected for a period of three months, has an annual EUI of about 12.1 kBtu/ft^2.



Central Plant Energy Use Intensity

End Use Category	Model 1 – Pre-retrofit Design	Model 2 – Proposed Design	Model 3 – Actual Design	
	Annual EUI (kBtu/ft^2)	Annual EUI (kBtu/ft^2)	Annual EUI (kBtu/ft^2)	Percent Savings over Model 1
Chillers	11.8	8.3	6.9	42%
Chilled Water Pumps	9.3	2.0	1.2	87%
Condenser Water Pumps	5.6	3.2	2.5	56%
Cooling Tower Fans	0.3	0.1	1.5	N/A
Total	**27.0**	**13.6**	**12.1**	**55%**

Models 4 through 7 were created to assess energy savings for the large production stage. Model 4 is the large production stage pre-retrofit design baseline, representing existing performance. Model 5 represents energy saved at the large production stage following an adjustment to the operating profile, mainly due to reduced hours and part load operation. Model 6 reflects energy saved following EEMs implemented at the central cooling plant, due to the increased efficiency of chilled water production. Model 7 is the actual design for the large production stage, after the central plant efficiency improvements have been taken into account.

Model 4: Pre-retrofit Design, Large Production Stage

Model 4 represents the existing operation of the large production stage. This model has an annual EUI of approximately 91.3 kBtu/ft^2.

Model 5: Pre-retrofit Design, Large Production Stage (Revised)

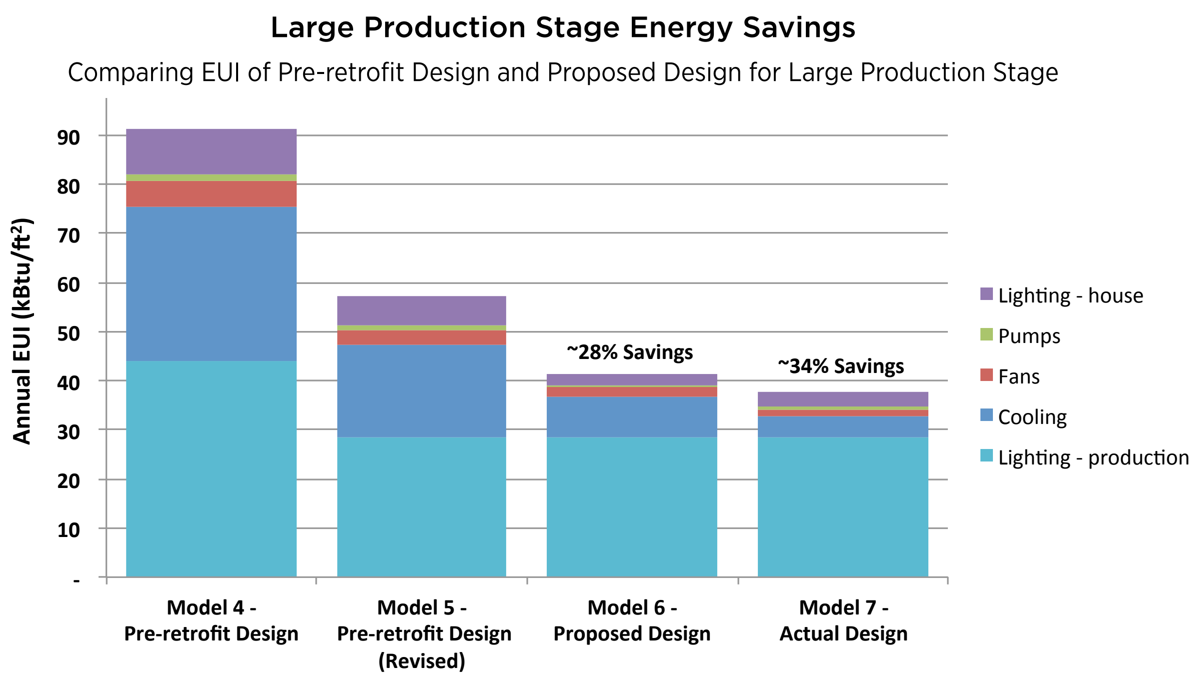
Model 5 represents simulated energy use factoring in adjusted operation compared with the first measured baseline. This model has an annual EUI of approximately 59.2 kBtu/ft^2.

Model 6: Proposed Design, Large Production Stage

Model 6 takes the revised simulated baseline (Model 5) and adjusts for the operating efficiency of the central plant following installation of the new chiller, connection of additional load to the closed loop and interconnection of CP1 and CP2. This model has an annual EUI of approximately 41.5 kBtu/ft^2.

Model 7: Actual Design, Large Production Stage

Model 7 uses measured energy data following the implemented retrofits, to estimate annual energy savings, having factored in improved efficiency at the central plant. This includes replacement of the existing air handler with a unit incorporating an automatic airside economizer and replacement of the direct evaporative cooler with a closed chilled water coil. This model has an annual EUI of approximately 37.6 kBtu/ft^2.



Large Production Stage Energy Use Intensity

End Use Category (electricity)	Model 4 – Pre-retrofit Design	Model 5 – Pre-retrofit Design	Model 6 – Proposed Design	Model 7 – Actual Design	
	Annual EUI (kBtu/ft^2)	Annual EUI (kBtu/ft^2)	Annual EUI (kBtu/ft^2)	Annual EUI (kBtu/ft^2)	Percent Savings Over Model 4
Cooling	31.5	18.8	8.4	4.2	78%
Fans	5.9	3.2	1.8	1.5	53%
Pumps	1.3	0.9	0.5	0.5	43%
Lighting - house	9.40	6.01	2.4	3.9	50%
Lighting - production	44.0	28.4	28.4	28,4	0%
Total	**91.3**	**57.3**	**41.5**	**37.6**	**34%**

Expected Building Energy Savings from Implemented EEMs by End Use

Electricity End Use Category	Energy Savings
Cooling	980,000
Pumping	2,000,000
Fans	(190,000)
Lighting	25,000
Total Electricity	**~2,800,000**

Lessons Learned

From CBP work on the Fox Studios complex, the project team (Fox Studios, LBNL, ARUP, CTG, Glumac and DOE) learned lessons that can be applied more widely to other facilities, such as office or higher education campuses that have a range of central plants, mechanical systems, and buildings.

Grasping the Problem

To understand how to address energy efficiency upgrades for complex, legacy mechanical systems with a number of system types and variations, it is vital to develop an appropriate strategy. Fox Studios' existing cooling system was of various ages, with many variations on how cooling was produced and supplied, so the priorities for refurbishment or outright replacement and connection to the central plant were not immediately clear. At the outset, the problem appeared messy and difficult – which to some degree it was. However, by defining a key set of metrics and criteria to assess each condition against, a process to evaluate cooling systems was possible. First, a representative metric for the efficiency possible for the central plant was assessed, both in terms of kW/ton along with an understanding of the loading conditions that were best suited to maximize chiller operation at part load. Next, each stage condition, whether it had an open direct evaporative coil, or made use of stand-alone or portable equipment, was evaluated and compared against the energy performance available from an improved plant. Finally, economic evaluations of options for modifying the stage cooling delivery were made to vet investment decisions. Strategic metering of specific equipment, including portable equipment and chilled water delivery on the open and closed loop systems enabled the level of energy analysis needed to make these decisions.

Unlocking Strategic Benefits

Design of new cooling systems should ensure that methods of cooling supply are effective, robust, and flexible to meet a wide range of future needs of the facility. An assessment of overall supply constraints is critical in identifying the system's pinchpoints, be it on the capacity side or air distribution, with evaluations done from the central plant to the local supply. For Fox Studios, this included identifying instances where cooling required supplementation, either because cooling capacity at the building load was insufficient, or because the cooling demand placed on the central plant was beyond its supply capacity.

Preferred modes of operation and plant configuration

The site energy load analysis completed suggested that the conventional practice of installing multiple identical chillers would not be the preferred approach. Due to the duration of various load conditions it was confirmed that a combination of small (300 ton), medium (500 ton) and large (750 ton) chillers provided the opportunity to meet energy requirements while utilizing chillers to maximize part-load efficiency (and capacity) through effective prioritization and chiller staging according to load condition.

The Enduring Value of a Data Collection Program

Without measured data, the risk/reward assessment associated with energy analysis and energy efficiency improvements is tilted towards the negative. To realize the full benefits of retrofits such as this, the ability of the site to have trend data that can support real energy savings estimation is crucial. Fortunately, Fox had trend capabilities in place for the chillers, and this was able to be fully leveraged for this project. In addition to activating and storing existing trend points, more monitoring points were added at the medium and large production stages and trended separately to enable detailed energy assessments. For Fox Studios, these data were vital inputs to development of EEMs, controls and operating strategies and will contribute towards greater energy savings in the future. It was recommended to Fox that following commissioning of production stage EEMs in the future, a data monitoring program be implemented to monitor energy performance and ensure persistent energy and energy cost savings.

References and Additional Information

179D DOE Federal Tax Deduction Calculator.
http://apps1.eere.energy.gov/buildings/commercial/179d/

Database of State Incentives for Renewables and Efficiency.
http://www.dsireusa.org/

Energy Design Resources: CoolTools Chilled Water Plant
http://energydesignresources.com/media/2305/EDR_DesignGuidelines_CoolToolsChilledWater.pdf

Energy Design Resources Design Brief: Chiller Plant Efficiency
http://energydesignresources.com/media/1681/edr_designbriefs_chillerplant.pdf

Greenhouse Gas Equivalencies Calculator:
http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results

Meier, A. K. 1984. "The Cost of Conserved Energy as an Investment Statistic." Berkeley, CA: Lawrence Berkeley National Laboratory.
http://repository.tamu.edu/bitstream/handle/1969.1/94751/ESL-IE-84-04-109.pdf?sequence=1

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

EERE Information Center
1-877-EERE-INFO (1-877-337-3463)
www.eere.energy.gov

15-EE-1761 • May 2015

Printed with a renewable-source ink on paper containing at least 50% wastepaper, including 10% post consumer waste.